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A Hybrid Framework for Restaurant Recommender System

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Abstract : Having healthy food and a regular diet are some of the most efficient mechanisms to control chronic diseases such as hypertension and diabetes. The existent systems do not provide mechanisms to allow people in such conditions to easily find restaurants providing suitable food for them. Under these circumstances, this study proposes a design of a conceptual framework for restaurant recommender system to improve people's decision-making process of choosing restaurants providing food according to their health conditions and preferences. The framework includes a user personal profile module, graphical user interface, database, knowledge base, and ontologies containing the restaurant menu items and their respective nutritional information. A prototype system has been developed to test the performance of the framework. The tests show that this framework can be used for the purpose that was conceived.

Keywords: Recommender System, ontology, restaurant, food, chronic diseases.

I. Introduction

Food is a fundamental necessity for any human being. It contains various nutrients (such as carbohydrates, fats, proteins, minerals, and vitamins) which are vital for the growth, development, and the maintenance of a healthy body (Manuel, Montalbán, & Riquelme, 2016). Likewise, these nutrients play a major role in meeting the special needs of people with health problems.

As a result of the busy lifestyle that most people have, eating out has become a common activity in modern societies. Despite this habit being useful to some people, it appears to be dangerous to the health of those suffering from chronic diseases.

According to the World Health Organization (WHO), a chronic disease is a long-lasting human condition that cannot be cured but controlled; such as diabetes, hypertension, obesity, allergies, heart and respiratory diseases. This organization stated that chronic diseases are the leading cause of mortality in the world, representing about 60% of all deaths (WHO, 2016).

However, for people with such diseases, having healthy food and a regular diet is an essential factor in controlling and improving their health conditions.

Researches have shown that people who are aged or have health problems are more concerned about finding a place providing food according to their health conditions and after that they focus on the preferences regarding restaurant characteristics and types of food provided (Dziadkowiec & Rood, 2015; Kim, Raab, & Bergman, 2010; Lee, Choi, & Zhao, 2009).

Nevertheless, since not everyone is an expert in nutrition, manually evaluating each menu item of the restaurants becomes time consuming and may lead to poor decisions.

The present study aims to propose a novel framework in order to support people with chronic diseases and without any nutritional knowledge to find restaurants providing food according to their health conditions and preferences. This framework can be used for restaurant recommender systems.

II. Related Works

Several researchers have proposed recommender frameworks to suggest food according to people's needs and preferences. Snae and Brückner (2008), for instance, designed a food-oriented ontology-driven system (FOODS). FOODS is an expert system for food and menu planning for the restaurants, hospitals, clinics, or home. It provides a food ontology to allow users to search for food menu.

A group of researchers from King Mongkut's Institute of Technology Ladkrabang, in Bangkok, developed a food and nutrition ontology using a knowledge-based framework to support healthcare applications, meal suggestion system for hospital patients, or to support preventive health care (Suksom, Buranarach, Thein, Supnithi, & Netisopakul, 2010).

Sivilai, Brückner and Snae (2012) developed a personalized food and nutrition planning system based on food-oriented ontology working together with an expert system which provides proper meals according to the user's personal conditions. This system was designed specially to assist hospital staff in suggesting food and nutrition plan for the older patients taking into account their physical conditions and preferences.

An intelligent diet food recommendation multi-agent to help people to get healthy information easily in order to have a balanced and healthy diet was proposed by Prakash and Sivakumar (2013).

These studies only dealt with the situation where people want to know which food to eat and how to prepare it, whereas the present research focuses on the situation where someone, in a particular geographical area, wants to find restaurants providing food according to his or her health condition and preferences in terms of the food and restaurant. Instead of just helping people to identify the most appropriate food for them, this study proposes a mechanism to collect the menu items of the restaurant ontologies and classify them based on the health status of the user.

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III. Restaurant Recommender Framework

This section describes the proposed conceptual framework for restaurant recommender system (figure 1).

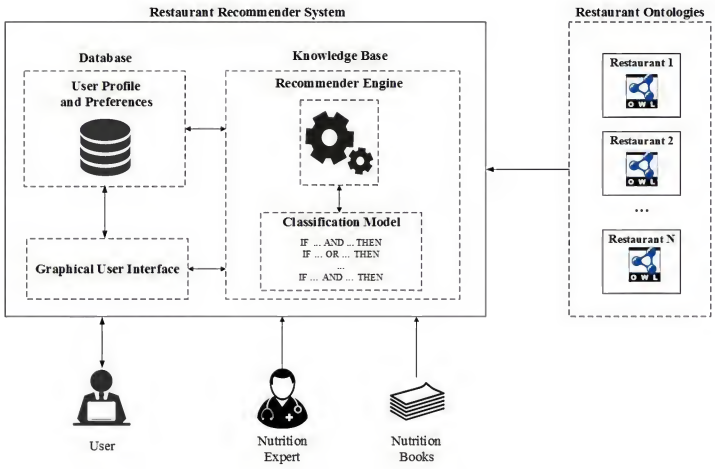

Figure 1: Hybrid framework for restaurant recommender system.

The proposed framework is composed by the following components:

a) **Graphical User Interface**: it allows the user to register his or her personal details, set preferences, and ask for recommendations.

b) **Restaurant Ontologies**: each restaurant must provide its information (restaurant features and menu items with the respective nutritional information) on the Web so that the recommender engine will be able to get it as a Web service. The restaurants will provide this information through ontologies by the use of Semantic Web technology.

c) **Database**: the user personal information, health condition, and preferences are stored in the database component.

d) **Knowledge Base**: the construction of knwoledge is based on the restaurant ontologies, user preferences, and models. Two classification models are proposed: one to classify restaurant menu items according to the user's health condition and the other to categorize restaurants based on user preferences. The recommender engine queries the information from the restaurant ontologies, classify them using these models, and then make appropriate recommendations. The recommendations depend on the details provided explicitly by the users.

IV. Ontology Design

A restaurant ontology was created as part of this research. It contains nine classes. All classes derive from the class Thing. A Thing can be a Restaurant, Restaurant Type, Restaurant Decor, Restaurant Service, Restaurant Cost, Menu Item, Food Category, Food Cuisine, and Cooking Method, as illustrated in figure 2.

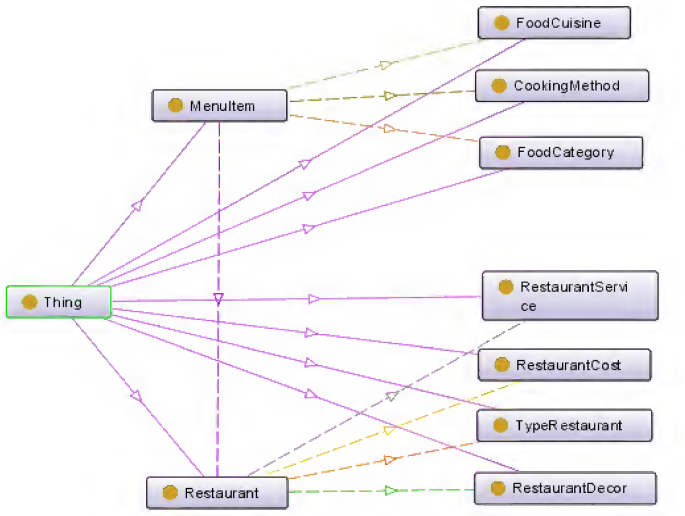

Figure 2: Restaurant Ontology.

The main class of this ontology graph is the class Restaurant. It contains the main attributes of the restaurants such as name, address, branch code, email, opening hours, and all other restaurant information. The class Restaurant is related to all others. The table below describes the classes and their respective relations:

Subject (Class)	Predicate (relation)	Object (Class)	Description
Restaurant	is	Type Restaurant	Specifies the restaurant type (coffee shop, casual, classic, or fast food)
Restaurant	has Cost	Restaurant Cost	Specifies the cost category of the restaurant in 5-scale
Restaurant	has Decor	Restaurant Decor	Specifies the decor category of the restaurant in 5-scale
Restaurant	has Service	Restaurant Service	Specifies the service category of the restaurant in 5-scale
Menu Item	belongs to Restaurant	Restaurant	A restaurant can have many menu items
Menu Item	belongs to Category	Food Category	A menu item can be a pizza, sandwich, fish, meat, dessert, beverage, so on and so forth.
Menu Item	Belongs to Cuisine	Food Cuisine	A menu item belongs to a certain kind of cuisine (African, Arabic, Chinese, Malay, Indian, Western, so on and so forth)
Menu Item	is Prepared	Cooking Method	Specifies the preparation mode of the menu item. It can be cooked, fried, baked, grilled, so on and so forth.

Table 1: Ontology classes relation.

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V. Restaurant Recommender System

In order to validate the conceptual framework, a Web-based restaurant recommender system was implemented. The proposed recommender system starts when a user who suffers from a certain kind of chronic disease (e.g., diabetes or hypertension) wants to find a restaurant that provides food according to his or her health conditions and preferences. If the user is already registered, then the user can log in. Otherwise, the system asks the user to register him or herself by providing the personal information and the respective(s) chronic disease(s).

Once registered, the user is required to set his or her preferences regarding the restaurant features. After that, the user can search for restaurants around his or her location by typing the address.

The recommender engine is responsible for locating all of the restaurants within the vicinity of the user; and classifying their menu items according to the health conditions of that particular user. To mention that, it has to query the restaurant ontologies available on the Web to get the restaurant data.

If a restaurant provides at least one menu item suitable for the user, then the recommender engine can check if this restaurant meets the user preferences. Otherwise, this restaurant is not worth being recommended.

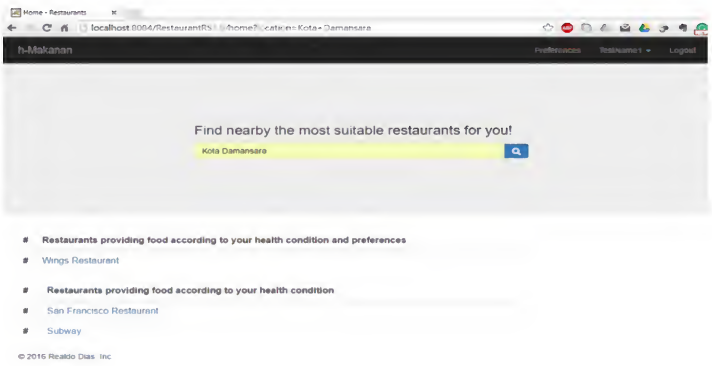

Figure 3: Recommendation results.

The recommender engine clusters the restaurants based on their features to verify if a restaurant satisfies the preferences of a particular user. After that, it collects the preferences initially set by the user or the restaurants he or she liked and then it assigns each one of these preferences to a certain cluster. If a restaurant belongs to the same cluster of the user preferences, then this restaurant meets the preferences of that user.

The restaurant recommender system provides two recommendation lists, as can be observed in figure 3. One list contains the restaurants having food according to user's health condition and preferences, and the other one includes the restaurants providing only food according to user's health condition.

To mention that this system was implemented based on the Web platform and written in java technology. The JSP (Java Server Pages) framework was used to create the Web pages based on HTML, XML, Java Servlets, JSTL (JSP Standard Tag Library), CSS, and JavaScript. MySQL 5.6 was used as a database management system (DBMS) and Apache Tomcat 8.0.15 as the webserver application. For the ontology development was used Protégè 4.6 and SPARQL as the query language. The machine learning software used for Data Mining tasks was Weka 3.6.

VI. Conclusion and Future Works

After reviewing the literature and analysing several frameworks, this research project proposed the design of a personalized recommender framework to support people in finding restaurants providing food according to their health conditions and preferences even without any nutritional knowledge. The framework is based on Semantic Web technology that allows it to get information from several restaurant ontologies created as part of the present research.

A prototype Web application was developed to validate the proposed framework. Based on the results of the experiments conducted, this system has shown that it can be used for the purpose that it was conceived. By providing a location address, the recommender system provides the restaurants having food according to the health condition and preferences of a particular user.

Future work involves the implementation of the following features: (a) the system should allow the users to rate menu items and restaurants so that it would be able to know more about the user preferences and provide recommendations based on users similarities (Collaborative Filtering approach); (b) it should also implement a user registration mechanism based on the Semantic Web in order to get more user information in an easy-to-share way; (c) it is necessary to evaluate the performance of the proposed solution in a real case scenario by applying all the fundamental evaluation metrics of a recommender system such as performance or response speed, reliability, confidence, robustness, security, and privacy.

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